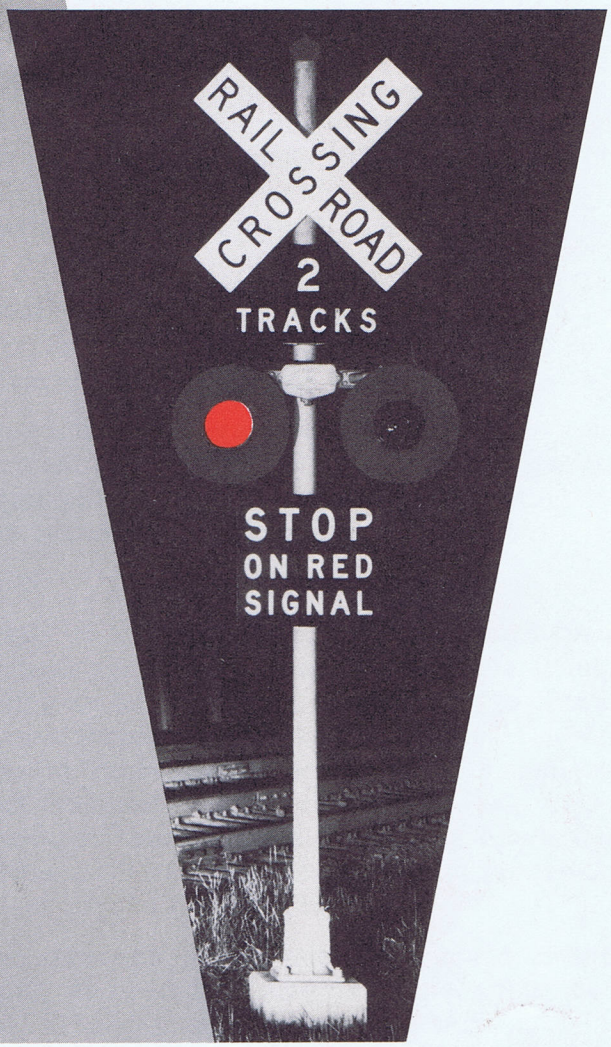
UNION DEVELOPMENT U.D. 285

UNION SWITCH & SIGNAL . . . SWISSVALE, PA.
DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY



UNION AFO

for highway crossing protection

AFO equipment for highway crossing protection

INTRODUCTION

Designed especially for longer track circuits and greater safety required for control of highway crossings, Union Audio Frequency Overlay (AFO) equipment eliminates the need for and, therefore, the initial and maintenance costs of line wires, insulated joints and impedance bonds. The significance of these factors is obvious in welded rail and electrified territories. Furthermore, fail-safe design provides highway crossing protection (except in electrified territory) without the need for coding.

With this equipment, similar in principle of operation to conventional AFO equipment, approach circuits long enough (4000 feet) to give 20 seconds warning in advance of a train traveling 136 mph may be operated.

Completely transistorized and designed to operate from a nominal 10 or 12-volt battery, this equipment has been tested on the basis of a minimum a-c ballast resistance of three ohms per 1,000 feet, a minimum shunting sensitivity of 0.06 ohms, and a maximum receding ringing distance of 100 feet.

CIRCUIT DESCRIPTION

Composed primarily of a transmitter, receiver and associated relay, the equipment can be arranged for control of a typical single-track, two-direction-running highway crossing as illustrated in Figure 1. The transmitters, each of a different frequency, are located at the starting points. Each receiver, also of a correspondingly different frequency, is located on the opposite side of the crossing from its associated transmitter. Overlapping the two AFO circuits creates the equivalent of an "island" track circuit. Receding movements will normally permit energization of the AFO relay on the far side of the crossing when the last axle is less than 100 feet beyond the crossing.

If the length of the approach circuit does not exceed 2500 feet (20 seconds warning time at 85 mph), the receiver may be connected to the rail in the usual rail-to-rail or multiple arrangement as shown in Figure 1.

For a 2500 to 4000-foot approach warning distance, the receiver must be inductively connected to the track with a 100-foot wire loop laid parallel to and between the rails as shown in Figure 2. This is necessary to insure a shunting sensitivity of at least 0.06 ohms throughout the entire length of the approach circuit. With the circuit shown (Figure 2), the input to the receiver is obtained from the voltage induced into the loop by AFO current in the rails. With infinite ballast resistance and an unoccupied track, AFO current is only that which flows through the output circuit of the transmitter for opposite direction of traffic. The receiver is so adjusted that even this small amount of residual AFO current will hold the AFO relay up.

The loop circuit conductor may be uninsulated wire such as stranded fouling bond wire stapled to the top of the ties approximately six inches from the inside base of the rails. If a shorter loop is desired, multi-conductor insulated cable may be used. Thus, if the desired loop length is 50' a two-turn loop must be used.

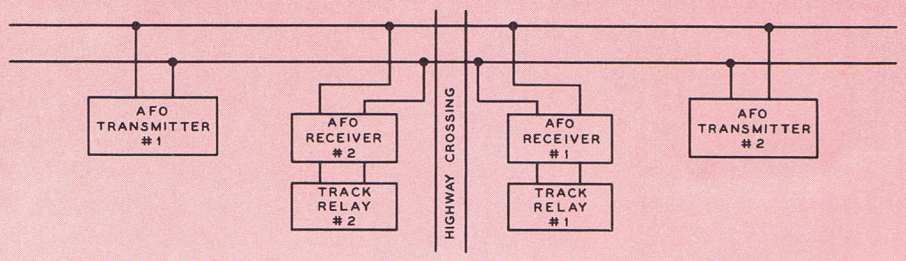


Fig. 1

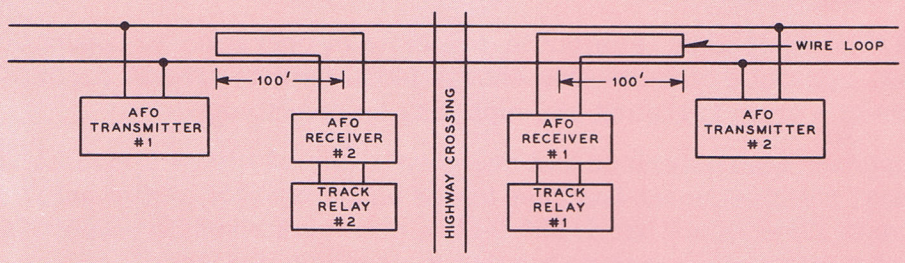


Fig. 2

The shorter multi-turn loop can be used to reduce the receding ringing distance however, only as the length of the approach is reduced below 4000 feet.

EQUIPMENT DESCRIPTION

TRANSMITTER

Two styles of transmitters have been developed for highway crossing protection to be utilized for the approach circuit lengths desired.

For those circuits which do not exceed 2500 feet, the transmitter is similar in size, power output level and appearance to those employed in switch lock releasing circuits. (See Figure 3).

If the desired circuit length is between 2500 and 4000 feet, a larger transmitter having a power output capacity approximately ten times that of the conventional transmitter is required. To accommodate the additional power output, this transmitter is equipped with a ventilating case for heat dissipation. (See Figures 4 and 5).

Both models, however, consist of an audio frequency oscillator followed by a Class A amplifier stage and a push-pull Class B output stage. A series-tuned filter in the output stage allows the transmitter to be connected across the rails without interference from or to conventional signal circuits.

Standard transmitter frequencies are 1.0KC and 1.5KC for the higher-power transmitter and 1.0KC, 1.5KC and 1.95KC for the lower-power model. However, provision for other frequencies can be made if required.

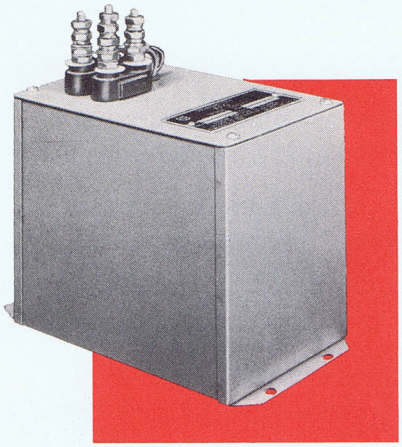


Fig. 3A . . . Transmitter

RECEIVER

Because highway crossing control circuits are vital, the AFO receiver (Figure 6) utilized for this purpose has been designed for fail-safe operation. Derangement, of any kind, that could falsely energize the associated relay immediately renders the receiver inoperative. This reliability is achieved by incorporating into the receiver self-checking design features including four tuned circuits arranged in cascade.

The input circuit of this unit includes a filter which, while blocking all other a-c frequencies and direct current, passes only the AFO tone. A two-stage transistor amplifier stage follows the filter. The output stage is a push-pull class B transistor amplifier. A rectifier converts the signal from the output stage to direct current. This voltage is then fed to the receiver output terminals for connection to the control relay.

The receiver includes two output voltage adjustments. Coarse adjustments, to take care of wide differences in track circuit length, are made by shifting jumper straps on four external terminals. These are located on the top of the case along with the track, relay and battery terminals. Spaces between the output adjustment terminals are marked 240, 1K and 8. 2K. Jumper straps connected between the terminals, to cover one or more of these markings, will short resistors of values corresponding to the markings. The receiver output increases when resistance is thus shorted. The three jumper straps are all installed for the longer approach distances. As the approach distance becomes appreciably shorter, one or more of the jumpers may be removed.

A slotted shaft potentiometer, mounted in the top of the receiver case, provides for fine output adjustment. This control is labeled LOWER-RAISE RELAY VOLTAGE.

LEAD SPECIFICATIONS

Lead resistances should not exceed the following values:

a.	Transmitter to rails	0.15 ohms
b.	Receiver to rails	0.15 ohms
c.	Receiver to relay	25.0 ohms
d.	Battery to receiver	0.5 ohms

Track leads should be arranged for minimum series inductance. Two-conductor cable is preferred, but a single conductor may be used if the wires to each unit are twisted together. If metallic-sheathed cable is used, it must be two conductor with both wires in the cable connected to the same unit.

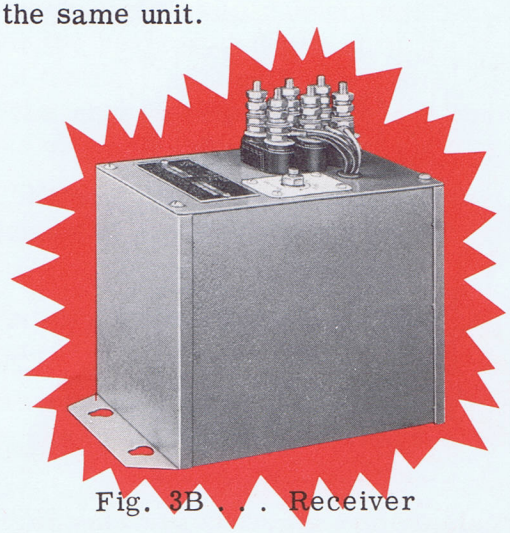


Fig. 3B . . . Receiver

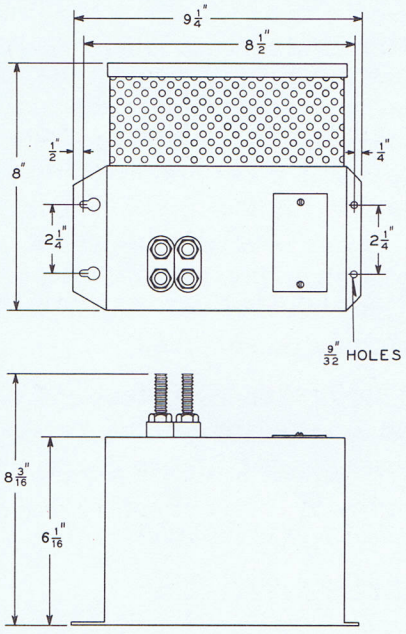


Fig. 4 ... Transmitter Dimensions.

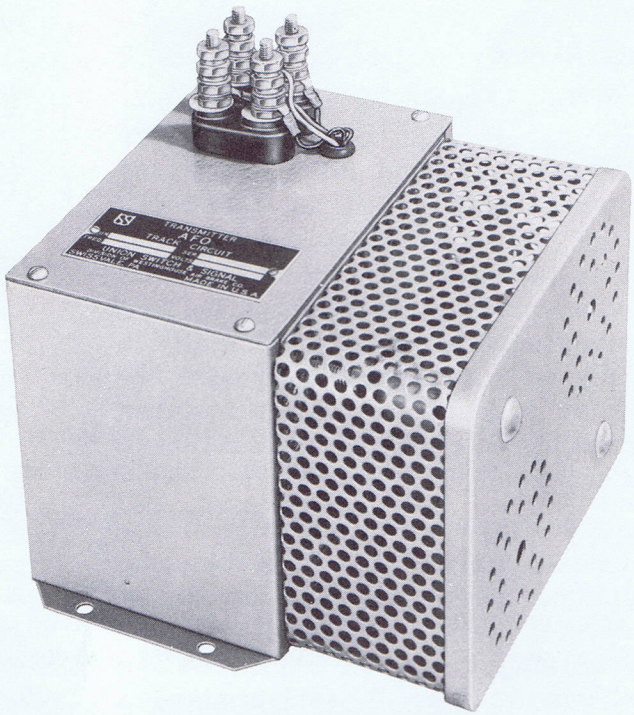


Fig. 5 ... High Power Transmitter.

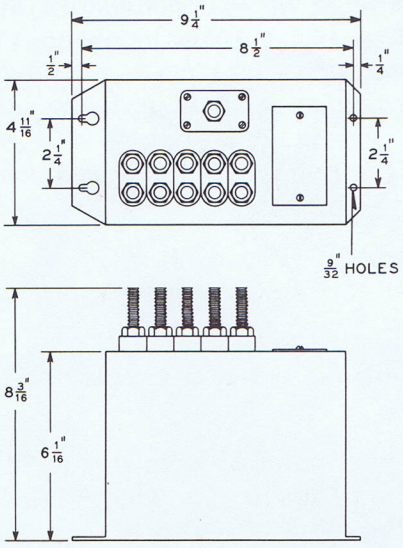


Fig. 6 ... Receiver Dimensions

RECEIVER RELAY

In order to hold the receding ringing distance to a minimum on non-code circuits the receiver relay must be a Style DN-22BH or PN-150-BH relay.

In electrified territory the input to the AFO transmitter should be coded at 180 code and the code following receiver relay should be a Style CD-F with tuned (180 code) decoding contact.

POWER REQUIREMENTS

Both the transmitter and receiver are designed to operate from a nominal 10-volt or 12-volt d-c source.

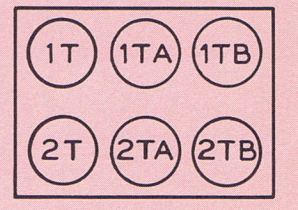
Power consumption at 10 volts for the high and low-power transmitters is 5. 5 and 0. 3 watts respectively.

Receiver power consumption at 10 volts is 0. 3 watts. This unit and the low-power transmitter may be operated from either primary cells or storage batteries.

OTHER INSTALLATION REQUIREMENTS

Style LCA Coupling Units. These units are used for passing the AFO tone around insulated rail joints, while blocking the d-c or low frequency a-c used in the track circuit. These units will pass either a 1KC or a 1. 5KC tone depending upon the terminal connections made. (See Figure 7). These units make it possible to extend an AFO circuit beyond a pair of insulated rail joints, while continuing to block the existing track circuit current. Connections are shown in Figure 8.

Fig. 7...



Terminal Arrangement of Style LCA 1000/1500∿ Track Coupling Unit.

Style VF Reactor. The Style VF reactor is used to block the AFO tone, while passing d-c and low frequency a-c. It may be necessary to install a Style VF reactor in series with one lead of existing track circuit rail connections which occur near the AFO equipment. The need for the reactor depends upon the impedance presented by the leads, their distance from an AFO unit installation, and the frequency employed. Figure 9 shows the relationship between minimum impedance, AFO frequency and distance.

For example, if the AFO frequency is 1. 5KC and "D" (Figure 9) is 200 feet, a VF reactor must be installed if the impedance at the AFO frequency of path BCDE is less than 0. 6 ohms.

The principle use for the reactor is in battery leads. Most d-c relay coils have an impedance above the minimums shown.

The VF reactor may also be used to make a precise point of shunting, if this feature is desired. Two arrangements are shown in Figure 10. The d-c resistance of the track reactor is 0. 075 ohms.

Mounting dimensions and terminal arrangements are shown in Figure 11.

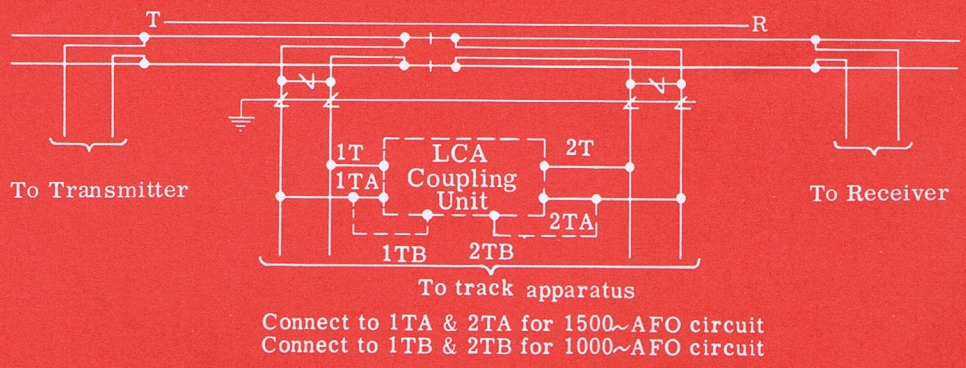


Fig. 8 . . . Connections at Insulated Joints to Extend AFO Rail Circuit.

Lightning Protection. All AFO track units require adequate lightning protection. Lightning surge voltages may enter a unit through connections to the track terminals or through connections to the battery terminals. These terminals must be protected as follows:

1. For protection against surges entering over the track terminals, install both series and shunt arresters (Pc. UN327989-12743-11 and Pc. UN314266-12743-11).

2. For protection against surges entering through the battery terminals of the AFO unit, connect a Lightning Surge Suppressor, (Figure 12A) between the battery and the AFO units as shown in Figure 12B. Only one suppressor is required to protect all AFO units within one instrument case. The suppressor may be omitted in only two instances:

    a. Where the case wiring is so arranged that the lightning surge enters the case over an a-c battery charging circuit and will reach the battery before it can reach an AFO unit, and where the battery is not connected to a line circuit. In such an instance, the external a-c line brought into the battery-charging rectifier must be shunted with a USG arrester (of suitable voltage rating) at the point where the line enters the case. Figure 12C.

    b. In the high power transmitter the reactor and capacitor of the lightning surge suppressor are integral parts of the unit and only the arrester (Pc. UN314266-12743-11 or Pc. UN314265-12743-10) is required.

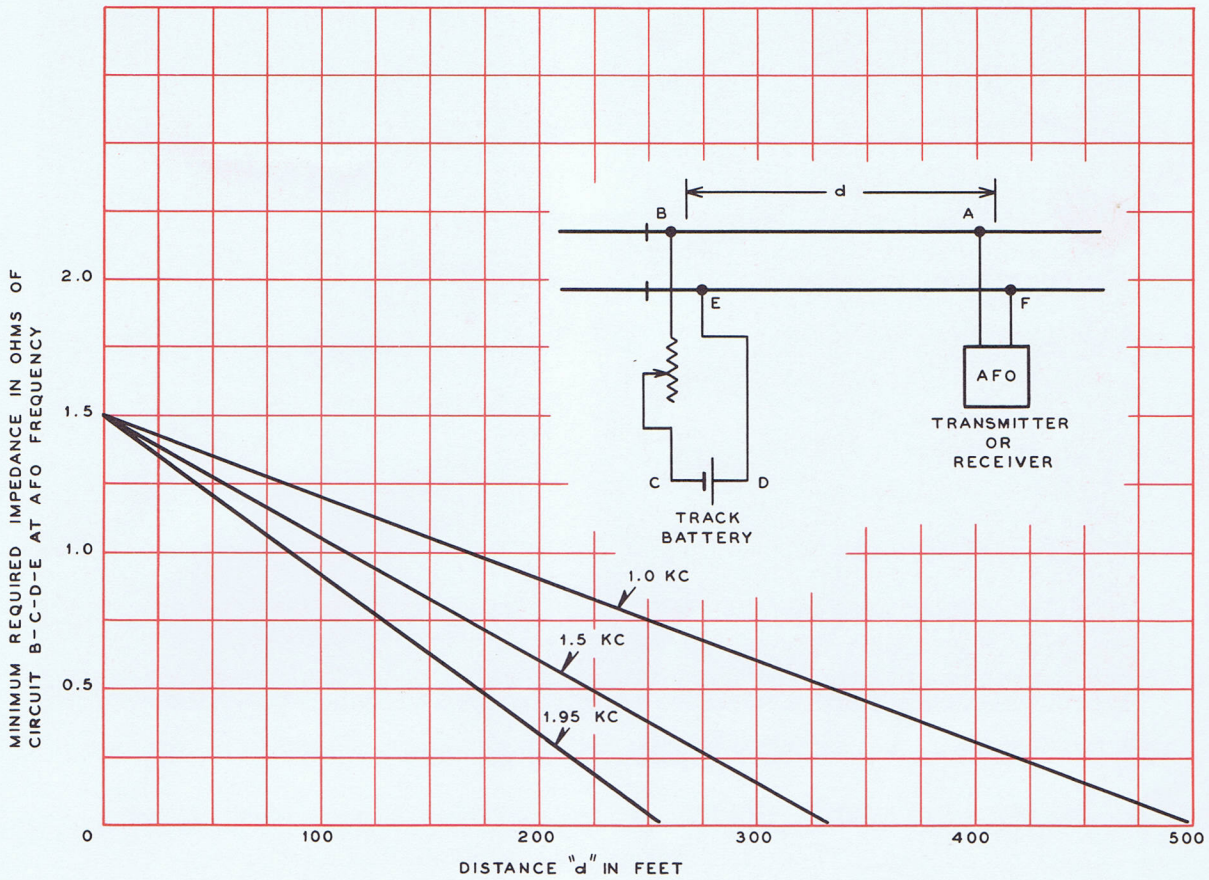
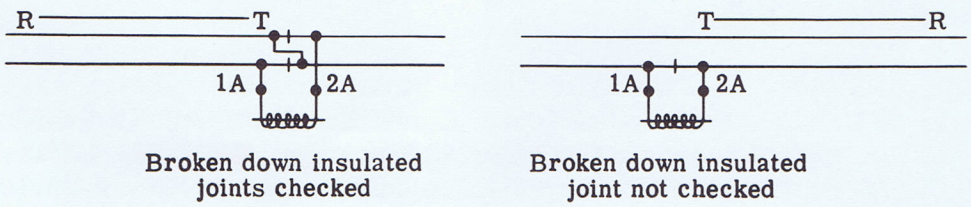


Fig. 9 . . . Requirements for Blocking Reactor



Broken down insulated joints checked

Broken down insulated joint not checked

Fig. 10 . . . Two Applications of Style VF Reactor to Limit Shunting Area of AFO Circuit

CIRCUIT APPLICATIONS

Typical circuit applications are shown on the following drawings and will be furnished upon request.

For non-electrified territory - Drawing SK22A7 - Sh. 1 and 2.

For electrified territory - Drawing SK22A8 - Sh. 1 and 2.

ORDERING REFERENCES

AFO Transmitters for circuits 2500' to 4000'
1.0 KC Pc. UN347119 F80010-Sh. 4
1.5 KC Pc. UN347120 F80010-Sh. 4

AFO Transmitters for Circuits under 2500'
1.0 KC Pc. UN373458 F80010-Sh. 4
1.5 KC Pc. UN373459 F80010-Sh. 4
1.95 KC Pc. UN373460 F80010-Sh. 4

Receivers for all highway crossing circuits
1.0 KC Pc. UN347199 F80010-Sh. 3
1.5KC Pc. UN344408 F80010-Sh. 3
1.95KC Pc. UN348793 F80010-Sh. 3

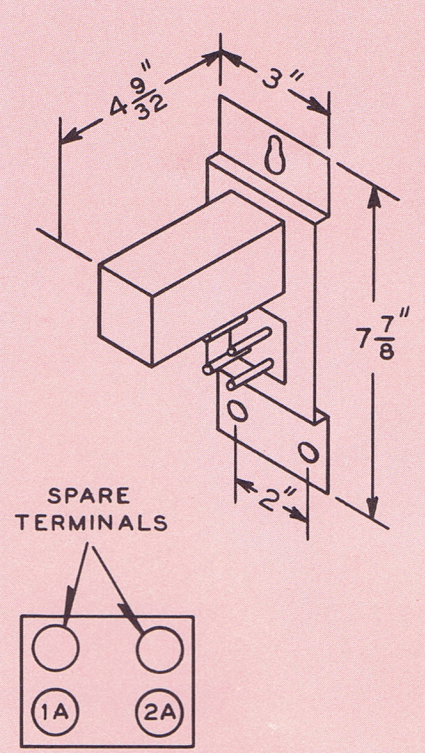


Fig. 11 . . . Style VF Track Reactor

Relays for AFO Receivers

Style CD-F - 500 ohms - 2F-2BLV - 1 Tuned Contact (180 code) UN373201 - C9452 Sh. 15*
180 Code Transmitter UN221552 - C9376 - Sh. 14*
Style DN22-BH - 500 ohms - 2F-2BLV - UN373702 - C9432 - Sh. 32
Style PN150-BH - 500 ohms - 2F-2BLV - UN332513-003 - D66000 - Sh. 24

* For electrified territory only.

Lightning Protection for AFO units

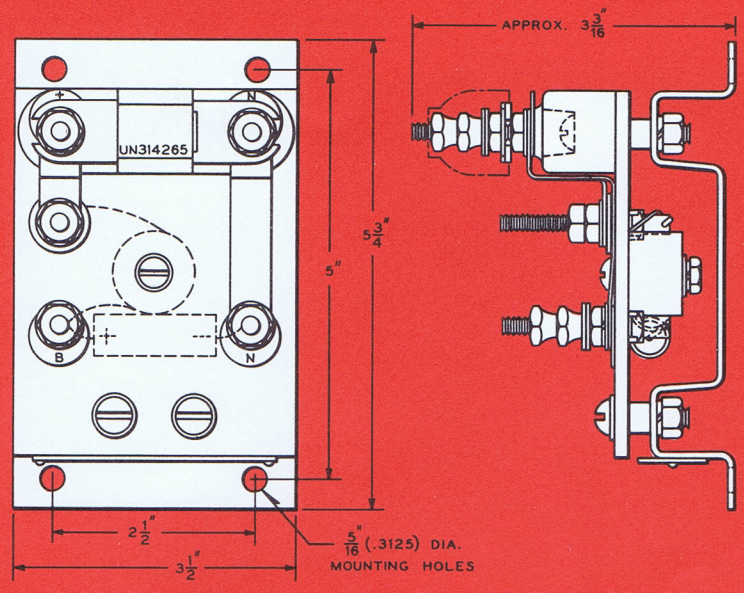
Style USG Shunt Arrester (with Term. Block) Pc. UN314266-12743-11
Style USG Shunt Arrester (no Term. Block) Pc. UN314265-12743-10
Style USG Series Arrester (with Term. Block) Pc. UN327989-12743-11
Style USG Series Arrester (no Term. Block) Pc. UN327988-12743-10
Lightning Surge Suppressor UN345048-12743-Sh. 15

Style VF Track Reactor

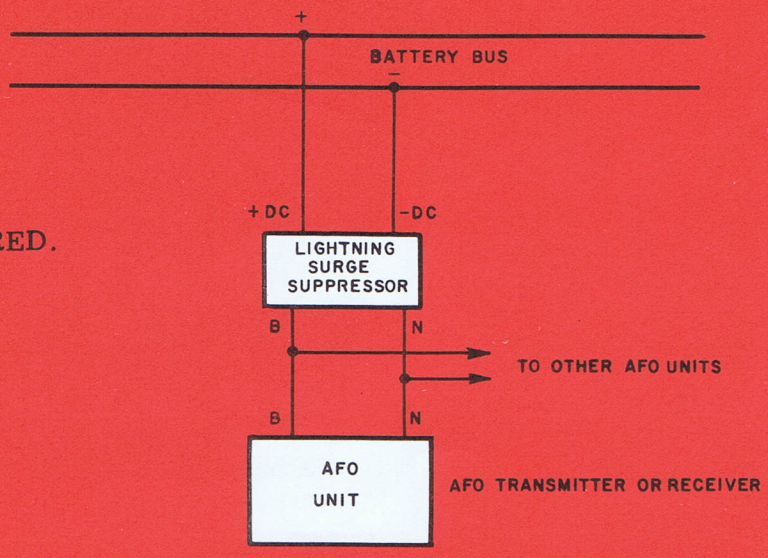
Track 0.075 ohms Pc. UN329271-C16743-135

Style LCA Track Coupling Unit

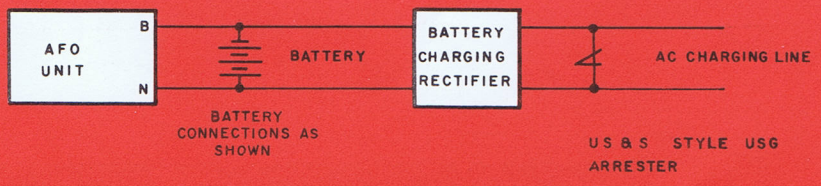
Track 1.0/1.5 KC Pc. UN329150-C16743-134



A. LIGHTNING SURGE SUPPRESSOR.



B. LIGHTNING SURGE SUPPRESSOR REQUIRED.



C. LIGHTNING SURGE SUPPRESSOR NOT REQUIRED.

Fig. 12 ... Use of Lightning Surge Suppressor.